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BACTERIA IN THEIR RELATION TO HEALTH AND DISEASE *

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II. SPECIAL SPECIES OF BACTERIA

We are now to look at some of the more interesting, and to us important, kinds of bacteria, and to see, as far as we can, wherein their life interests run counter to ours and by what means we are enabled to protect our interests against theirs. Before reaching the pathogenic forms I wish briefly to speak of one or two of the non-pathogenic species to which I have already alluded.

The favorite bacterium for experimental purposes is the one which I told you was the cause of the miracle of the Bleeding Host. Its peculiarities are so striking that it is recognizable at all times and without difficulty. It was one of the first bacteria studied, and early received the name *Micrococcus Prodigiosus,* which it has since retained. Yet it is not a globular bacterium, but a short rod—a bacillus, and not a micrococcus. In growing on nutrient gelatin it is only the colonies on the surface which show the characteristic pigment, which is at first pink and later a deep blood-red. The substance which in contact with the oxygen of the air produces this color is a product of the growth of the bacteria, and not the bacteria themselves. By certain changes in the nutrient medium it is possible to grow colonies of this bacterium which will not produce color, while the individual bacteria in the colonies cannot be distinguished otherwise from those which still retain the color-producing property. This process of growing a modified bacterium is called "at-

* Read before the nurses of Rochester City Hospital.

tenuation." It is of importance because it shows that the excretions of bacteria may be modified artificially.

The hay bacillus (*B. Subtilis*) is one of the most widely distributed of all bacteria. It takes its name from its being regularly found in hay and in vegetable infusions of all kinds. The formation of spores and a whole series of facts, afterwards found applicable to bacteria in general, were first noticed in the study of the hay bacillus. This bacillus grows very rapidly. Observers have stated that a cell can divide and become two new bacilli within half an hour, and keep up this rate of increase until the nutrient medium is exhausted. The hay bacillus is one of the species in which the organs of motion—flagella—have been distinctly seen at either end of the rods.

Blue milk, which was once thought to be produced by a special disease of cows, is caused by a bacillus which naturally is called the blue-milk bacillus (*B. Cyanogenus*). These bacilli are fond of oxygen and develop their color on the surface of the nutrient medium. On potato the growth is very rapid and characteristic. The culture-medium is saturated with the pigment.

Sea-water is the home of a special group of micro-organisms which possess the property of shining in the dark (*B. Phosphorescens*). In artificial cultures this property is readily observed. The most widely distributed member of this group will retain its light-producing power for months. If by becoming attenuated the bacilli lose this power, it may be restored at any time by adding two or three per cent. of common salt to the food medium.

In order that you may understand the action of pathogenic bacteria in producing disease in man and other animals it is necessary for me to lead you on to debatable ground. But I will give you as much fact and as little theory as possible, and the observed facts are sufficiently numerous to give the highest degree of probability to the theory. As you are aware by this time, bacteria are living beings which require a definite quantity of nutriment for their support. If they are parasitic,—existing upon or within another organism,—they take this nutriment from the organism which harbors them, and which may suffer thereby. The chief food which these parasites require consists of albuminous substances—the materials out of which body-cells are made. Another element of their food is oxygen, which they also take from the living tissues. But of still greater importance than what they take away from the tissues is what they leave behind. In the decomposition of albuminous matter, caused by bacteria, certain substances called *ptomaines* are produced. These possess extremely poisonous qualities, so that even small quantities suffice to kill the larger animals in a short time. Now, by the processes of

isolation and cultivation of pure cultures, investigators have found that the principal pathogenic species of bacteria excrete specific substances out of their nutriment which prove to be genuine *toxines* or poisons. These poisons when inoculated into susceptible animals produce some of the symptoms which would be caused by inoculation of the bacteria themselves. An animal may be either susceptible or immune to a given disease. If susceptible, he may acquire the disease under proper conditions; if immune, he would not acquire the disease. E. S. Abbot defines infection and immunity as follows: "Infection is due to the introduction and spread throughout the body of bacterial poisons . . . derived from the germ-substance of the bacteria. Resistance to infection is *natural* by means of physiological and chemical processes, and *artificial* by means of antiseptics, induced tolerance for the poisons, and increased capacity to destroy the poisons and germs. Induced tolerance is secured by the administration of increasing doses of the poison, beginning with a non-toxic dose. Increased capacity to destroy germs and poisons is secured by the administration of the serum of animals in whom induced tolerance has been established. The immunity conferred by these methods is more or less temporary and is never absolute." To quote again from Fränkel: "We may safely lay down this proposition: The action of pathogenic bacteria is chiefly to be explained by their producing specific, extremely poisonous substances which seriously injure the organism, influencing it in a definite manner, and thereby causing definite, independent forms of diseases."

Pathogenic bacteria possess the ability to multiply indefinitely within the organism which they invade. Hence their excretions, the poisons, are constantly increasing in the body, so that the quantity of germs which invaded the body at its first infection is a matter of little moment. Another fact of importance is the discovery, made in 1880 by Pasteur, that under certain circumstances certain pathogenic micro-organisms lose their poisonous power to a greater or less extent without any other perceptible change. This diminution of virulence, or attenuation, which we have already noted in the case of the color-producing bacilli, was the stepping-stone from which Pasteur made his brilliant series of investigations which ended in protective inoculation. It is upon this principle that are founded the various Pasteur Institutes scattered over the globe. At these institutions immunity from hydrophobia is obtained by those who have been exposed to the disease by inoculation with the attenuated germ of this disease. This principle is doubtless the basis of the immunity against smallpox furnished by inoculation with the vaccine virus, although the specific germ of this disease has not yet been positively identified.